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Secretary

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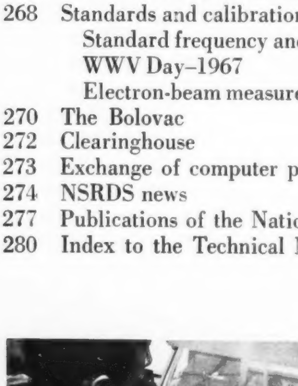

COVER

An improved process for making high-quality thin aluminum films has been developed at the Bureau. Using this process, Musti Narasimham separates an aluminum film from its crystal mount. (See page 262.)

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized into three institutes—

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

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Lloyd A. Weber operates the dead-weight gage in the pressure measuring system used to obtain data on the thermodynamic properties of oxygen.

OXYGEN DATA OBTAINED FOR AEROSPACE APPLICATIONS

Oxygen was first separated from liquid air by C. Linde in 1895, but until 1960 there was a paucity of data on the physical properties of oxygen below ambient temperatures. In fact, no significant measurements had been made on this element in the cryogenic temperature range for 40 years. In 1960 and 1961, Russian[1] and Belgian[2] scientists published new pressure-volume-temperature (P-V-T) researches on liquid oxygen, but they were limited in scope and there was disagreement between their data.

At present, oxygen is used as the propellant oxidizer in the Saturn, Centaur, and Atlas rockets, and also finds application in fuel cells and environmental control systems for space capsules. The recognized importance of oxygen in the U.S. space program, and the absence of comprehensive and accurate data for many of its physical properties, have caused the NBS Institute for Materials Research to undertake an extensive research program on the thermodynamic properties of oxygen. This investigation, which is under the direction of L. A. Weber, was started in 1964 at the Institute's Cryogenics Division at Boulder, Colo., and is sponsored by the National Aeronautics and Space Administration. This work has resulted in a comprehensive compilation of accurate P-V-T tables for oxygen.

During the first phase of the program, apparatus that had been designed and developed by R. D. Goodwin, for measuring the thermal and P-V-T properties of fluid parahydrogen, was modified to measure the same properties of liquid oxygen.

Most modifications in the apparatus were made to insure the safe handling of liquid oxygen, which reacts spontaneously with a great many substances. Precautions were taken to guard against materials in the equipment, or contaminants in the system, that could initiate or sustain unwanted chemical reactions.

From 1965 to late 1966, precision measurements were conducted on the P-V-T properties of oxygen from its triple point to room temperature, at pressures up to about 350 atmospheres, and for both the liquid and vapor phases. A fundamental understanding of the properties of both phases is necessary for engineering design since oxygen in cryogenic systems is usually close to saturation and the simultaneous existence of both liquid and vapor phases is common.

The results of this two-year project consist of approximately 1600 closely spaced P-V-T data points having ac-

continued

OXYGEN DATA *continued*

curacies within 0.01 percent in pressure, 0.001 K in temperature, and 0.1 percent or better in density. The magnitude of this contribution is apparent when it is realized that these data comprise about two-thirds of all P-V-T data ever measured on oxygen. The completed P-V-T data are now being smoothed analytically and interpolated for the purpose of constructing tables of smooth P-V-T values.

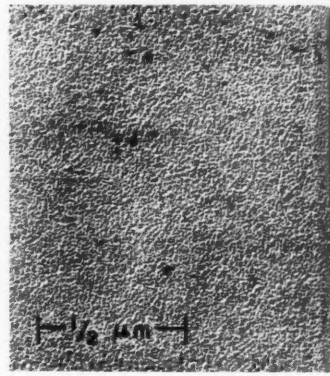
Another phase of the work, recently begun, will consist of the measurement of the heat capacity of oxygen at constant volume, throughout the same range of conditions as the P-V-T measurements. When these rather difficult heat capacity experiments are completed, the resulting data will be combined with the P-V-T values, and tables of the thermodynamic functions (internal energy, entropy, enthalpy, specific heat, and velocity of sound) will be made.

The completed NBS program of research on the thermodynamic properties of oxygen will include experimental and computational results on P-V-T behavior, orthobaric densities, the critical constants, the freezing liquid P-V-T relation, the virial coefficients, the specific heats of saturated liquid, the constant-volume specific heats for a wide range of compressed fluid states, the heats of vaporization, the Joule-Thomson inversion curve, and tables of thermodynamic functions and derived specific heats at constant pressure.

[1] **The density of liquid oxygen on the saturation curve**, by D. L. Timrot and V. P. Borisoglebskii, Soviet Phys. JETP **11**, No. 6, 1248–1250 (1960), transl. of Zh. Eksperim. Teor. Fiz. **38**, 1729–1732 (1960); see also, **Experimental investigation of the density of liquid oxygen at −190 °C to −120 °C and pressures to 200 kg/cm² including the saturation curve**, by D. L. Timrot and V. P. Borisoglebskii, transl. of Inzh. Fiz. Zh. Akad. Nauk Belorussk. SSR **4**, No. 1, 3–13 (1961), NBS Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, Order No. 61 21722 (Apr. 1961).

[2] **Density of liquid oxygen as a function of pressure and temperature**, by A. Van Itterbeek and O. Verbeke, Cryogenics **1**, No. 2, 77–80 (1960); see also, **The variation of the density of liquid nitrogen and liquid oxygen as a function of pressure**, by A. Van Itterbeek and O. Verbeke, Cryogenics **2**, No. 2, 79–80 (1961).

THERMAL REGENERATION OF IRON OXIDE FILM

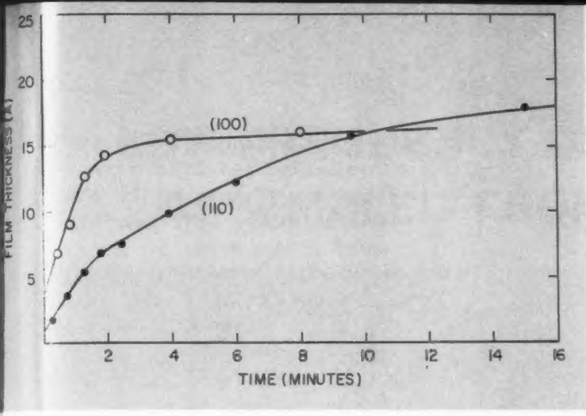


Electron micrographs of the (100) iron surface: (left) before thermal regeneration and (right) after 12 thermal regeneration and oxidation cycles. Note the roughening caused by phase transformations upon vacuum annealing and cooling.

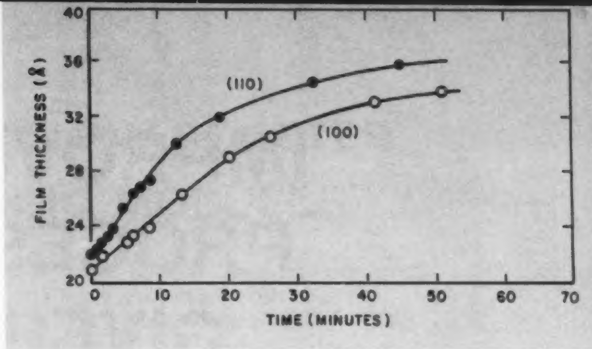
When some metals are exposed to oxygen, an oxide film forms on the metal surface. This film, when grown, protects the metal from further oxidation at room temperature. Previous studies have shown that on iron this protective film could be further grown, or regenerated, after it had reached a limiting thickness at room temperature. The mechanics of this process, however, have not been clearly understood.

A recent study,[1] by H. T. Yolken and J. Kruger of the NBS Institute for Materials Research, dealt with thermal regeneration of oxide film growth on (100) and (110) iron surfaces. In this study, film growth was regenerated several times by vacuum annealing at elevated temperatures and re-exposure to oxygen after cooling. Data obtained in the study give a plausible explanation of the mechanisms involved in the regeneration process. It is hoped that such studies will eventually lead to improved methods for preventing or reducing corrosion.

The investigation results indicate that thermal regeneration is caused by a phase change of the oxide film from Fe_3O_4 to FeO on annealing at about 400 °C or above. The phase change causes thin areas to appear in the oxide

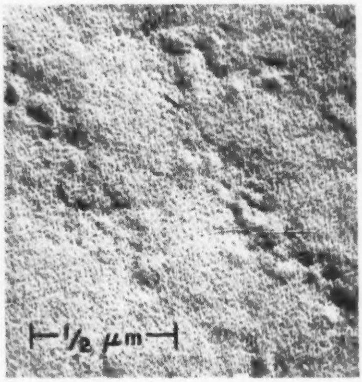


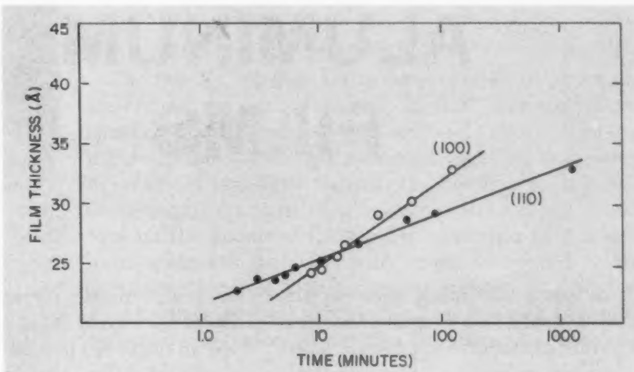
Film thickness versus time shows the rate of formation of oxide film on both (100) and (110) iron surfaces. The leveling of the curves indicates a limiting film thickness has been reached.



Film thickness versus time shows the amount of growth for one regeneration cycle.

Plots of film thickness versus log time show the logarithmic rate of formation of iron oxide film for several regeneration cycles.





film and some enrichment of iron in the film. Concurrently, during annealing, the adsorbed monolayer of oxygen anions is incorporated into the film. Upon re-exposure to oxygen the thin areas grow again to a limiting thickness. The enrichment of iron in the film also allows further growth.

In carrying out the investigation, smooth, clean, flat, strain-free surfaces were first prepared from floating-zone refined iron. In each case the specimen surface was allowed to reach a limiting oxide thickness. Next, oxygen was pumped out of the system until a pressure of 5×10^{-10} torr was obtained. The specimen was then thermally regenerated by heating to a given temperature (25 to 700 °C) by radiofrequency induction and cooling to room temperature. After cooling, oxygen was readmitted to the system at a pressure of 1×10^{-5} torr for further oxide growth. Growth could be reinitiated to a new limited thickness after each annealing until a final thickness of approximately 100 Å was reached.

Before regeneration, the film growths followed a film thickness-time dependence that was in agreement with earlier work on iron oxidation.[2] Plots of the data show rapid growth for the first few minutes and a slowing down of the growth rate after the film reached approximately 15 Å thickness. The slopes of the curves show a faster rate of growth for the (100) surface than for the (110) surface during the first few minutes of growth.

Curves for regenerated film growth show growth rates less than those for unregenerated growth. After an initial growth the curves for both (100) and (110) surfaces followed a logarithmic relationship with time.

In the study, film thicknesses were measured with an ellipsometer which relates film thickness to changing optical parameters. The ellipsometer was capable of detecting changes as small as 0.5 Å in film thickness. Specimen temperatures were determined by an infrared pyrometer. Gases in the system were analyzed by a magnetic deflection mass spectrometer capable of detecting partial pressures of 10^{-13} torr.

[1] For further details, see **Thermal regeneration of oxide covered iron (100) and (110) surfaces**, by H. T. Yolken and J. Kruger, J. Electrochem. Soc. **114**, 796 (1967).

[2] **Room temperature oxidation of iron at low pressures**, by J. Kruger and H. T. Yolken, Corrosion **20**, 29t (1964).

IMPROVED PROCESS GIVES HIGH-QUALITY THIN ALUMINUM FILMS

■ By using thin films, scientists are able to probe more deeply into the structure of matter. For example, when helium atoms gain or lose an electron, they radiate tiny packets of ultraviolet light; study of this light reveals new information on the properties of the atom. To make such studies, however, researchers have to separate this helium ultraviolet light from other background radiation. This can be done by using thin films as filters that transmit the ultraviolet but reflect radiation of longer wavelengths which are of lower energy.

The thin films used for this purpose may be of various materials, but aluminum is undoubtedly the most important vacuum ultraviolet transmitter-reflector known today. It has high normal-incidence reflectance in the wavelength region of about 1000 Å, and at wavelengths between 500 and 800 Å it is one of the better available materials for making grazing-incidence reflectors.

Recently, Paul Werner of the NBS Radio Standards Laboratory, Boulder, Colo., and Musti Narasimham, an NBS guest worker from India, developed an improved process for making high-quality, thin aluminum films 8 millionths of a centimeter thick.* Required for a Radio Standards Laboratory project, the films were produced for transmitting 304 Å radiation. It was necessary that they be self-supporting since they had to be removed from the substrate upon which they were deposited. The tendency for the substrate material to absorb some of the ultraviolet radiation necessitated their removal.

The NBS investigators, by evaporating common table salt onto an extremely smooth substrate crystal and then evaporating aluminum onto this coating of salt, are able to make better aluminum films than previous workers, and with a higher percentage of success. Two-thirds of their films can be used in research, while other scientists, using other methods, claim to get only one usable film out of every 25 to 30 that they make.

The films made by this process also have fewer pinholes to be patched than do films made by other processes. These few pinholes can be mended with conductive silver paint applied under a microscope by using two bristles from a brush.

Sodium chloride is more successful in the process than other salts mainly because it dissolves more quickly when placed in water, leaving the film floating on the surface. Another reason for the success of sodium chloride is that both sodium chloride and aluminum have similar cubical crystals. Other salts have crystals of different shapes which cause too many pinholes in the film.

Because thin films are very delicate, they must be bonded onto a support material before they can be handled. Mr. Narasimham developed a process for bonding the film to a fine mesh (covering an aluminum ring) which has been dipped into a dilute solution of formvar. After the film is deposited onto the mesh, the formvar is softened with fumes from ethylene dichloride and the mesh is bonded to the film.

Although NBS is at present using the films only in research into the structure of elements and to obtain improved performance in various radiofrequency standards, aluminum and other thin films have numerous practical applications in science and industry. Examples in the fields of physics and electronics are: reflection and transmission type interference filters with narrow and wide bandwidths; radiation detectors; coatings for image-forming devices; light intensifiers and solar energy converters; passive and active electronic film components, such as electrical resistors and windows in waveguides; thin film circuits; and superconducting film devices.

Messrs. Werner and Narasimham are now preparing data tables concerned with the filtering of ultraviolet radiation by aluminum thin films.

*A method using sodium chloride was suggested by Robert Conger of the NBS Boulder glass shop.

LOW-FREQUENCY DIGITAL PHASEMETER ASSEMBLED FROM LOGIC MODULES

J. E. McKinney compares the digital display of the NBS-developed phasemeter against the setting on a commercial phase generator (left). The oscilloscope (right) displays the two signals.

■ A phase-angle meter developed at the NBS Institute for Basic Standards gives digital indications of the phase angle (in radians) to four decimal places between two electrical signals from an arbitrarily low frequency to 10 kHz. Devised by J. E. McKinney of the Institute's rheology laboratories, the meter can be assembled from commercially available logic modules.[1] When used with a conventional digital frequency-ratio meter, it supplies precise values for the phase angle between two signals of the same frequency. The measurement is absolute and is referred to a time base, which may be derived from the NBS frequency standard. Its accuracy is better than 0.01 degree at 400 Hz and is expected to improve at lower frequencies.[2] The instrument is simple in design, inexpensive, easily portable, and requires little space in a laboratory.

The need for an accurate low-frequency phasemeter originated at NBS in certain types of rheological measurements on substances with long relaxation times. Although the phasemeter was designed specifically for use in measuring dynamic compressibility, particularly at the lower frequencies, it should prove useful as a general-purpose instrument for phase measurements. Potential applications include other types of mechanical measurements and low-frequency dielectric measurements.

The phasemeter is comprised of a logic circuit, which can be assembled from logic modules, and a preset frequency-ratio meter. Both the logic modules and the frequency-ratio meter are commercially available.

Basically, the phasemeter is a timing circuit which measures the average time interval between appropriate zero crossings of the two signals over an arbitrarily selected number of cycles. The reason for using many cycles of a signal is to reduce errors caused by random and incommensurable imperfections accompanying the signals and to average the timing errors between zero crossings. However, considerable ability to ignore certain types of sine wave imperfections, such as d-c offset, noise, a-c hum, and some harmonics, is inherent in the device.

Operation

The two signals that are to be compared in phase are applied to the inputs of two identical channels. These channels are connected to the "set" and "clear" inputs of a flip-flop multivibrator. Pulses corresponding to the zero crossings of one signal activate the flip-flop, while pulses corresponding to zero crossings at the other signal deactivate it. The output of the flip-flop controls a gate, which gates a clock signal. The gate output is applied to the numerator input of a frequency-ratio meter. The flip-flop also controls a single shot multivibrator which generates pulses corresponding to the zero crossings of only one of the signals. These pulses are applied to the denominator input of the frequency-ratio meter. The meter then reads the number of clock pulses passed through the gate for n zero crossings of either signal, where n is an integer arbitrarily selected and preset on the frequency-ratio meter. If, for example, only positive-going zero crossings of both signals are made effective, the digital display will be the product of the phase angle (in radians), clock signal, and the preset number n divided by the angular frequency of the input signals. If the signal frequency is unknown, it may be measured by repeating the above procedure with the gate held active for n zero crossings at input.

Supplemental Information

Several modes of triggering are available with the NBS-developed phasemeter. In the double-triggering mode, all zero crossings of both signals are made effective. These signals may have corresponding zero crossings (for example, both positive-going) or noncorresponding zero crossings (for example, one positive-going and one negative-going). The choice of the mode depends upon the character of the signals and the relationship between them. The more accurate measurements are obtained by using double triggering in which direct current offset is

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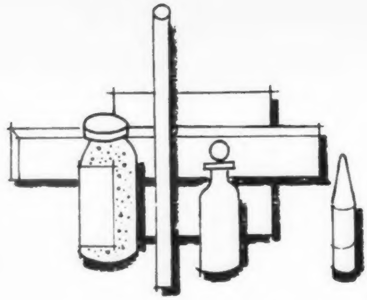
STANDARD REFERENCE MATERIALS



Standard Reference Materials are well-characterized materials disseminated by NBS to be used in calibrating and evaluating measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base. These materials are certified for chemical composition or for a particular physical or chemical property. They are used on-site in science and industry for calibrating the instruments and methods used for production and quality control of raw materials, chemicals, metals, ceramics, fuels, and radioactive nuclides in manufacturing processes and in research. This column regularly reports on the issuance of new and renewal Standard Reference Materials and on latest developments in the Standard Reference Materials Program.

FERROCHROMIUM (LOW CARBON)

Anything that is deliberately added to a metal during its manufacture to change the chemical composition or the resulting physical properties of the metal is generally called an "addition agent." Such additives have become critical components of the raw materials mix used to produce metals. With the advancing technology in the metals field, greater emphasis is now being placed on the control of melt compositions, on higher, and more reproducible, alloy efficiencies, and on the control of residual or tramp impurities in the addition agents which influence the finished product.

Ferroalloys make up a special class of "addition agents" which are used primarily in steelmaking. These iron alloys are so rich in some element other than carbon, that they can be used to introduce that element into molten steel to produce desired properties in the steel.

These alloys are sold on the basis of the amount of one or more elements contained in the alloy. Shipments of 100 to 500 tons are common in this industry which has gross sales approaching the $1 billion mark. For technical and accounting reasons, both producer and consumer need to have an accurate knowledge of the chemical composition of the ferroalloy involved. Because major ingredients of many of these ferroalloys must be imported, the Government also has a direct concern in ferroalloys.

To satisfy the needs of industrial users and the Government, the Bureau is preparing both renewals of the important ferroalloy standards and new ones. The first of these standards in the program to be made available is NBS Standard No. 196, Ferrochromium (low carbon).

The ferrochromium alloys are characterized by their content both of chromium and of undesirable impurities. As the United States has relatively few domestic reserves of chromium ores and is the largest consumer of chromium, it therefore has an important and increasing need for reliable standards.

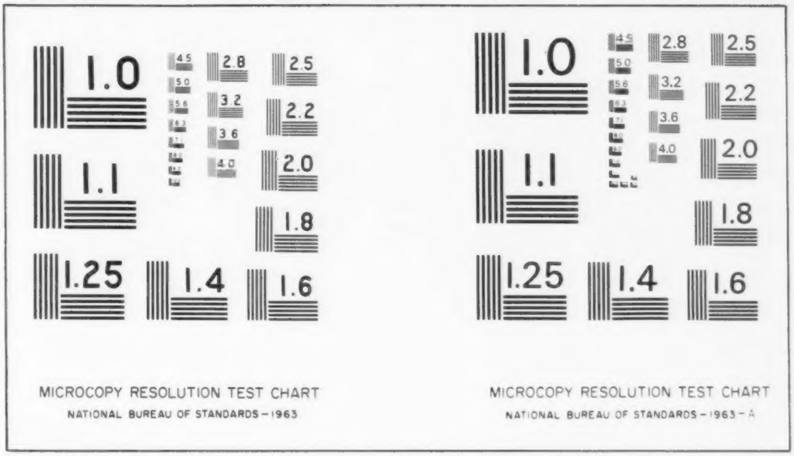
The new low-carbon ferrochromium standard was prepared using recently developed techniques for preparation of the fine particle size range required. This standard is a powder with a particle size range which passed through a 70 mesh sieve but was retained by a 140 mesh sieve. The provisional certificate issued with NBS No. 196 gives the values for carbon, chromium, manganese, silicon, and vanadium. This standard may be purchased in units of 100 grams of powder for $35.[4] The material for this standard was furnished to the Bureau by the Metals Division of Union Carbide Corporation.

MICROCHEMICAL STANDARD

A new microchemical standard reference material for checking microdeterminations of carbon, hydrogen, and nitrogen, has been issued with a provisional certificate. The new standard, NBS No. 148, was prepared from nicotinic acid (C_5H_4NCOOH), which titrimetric assay indicated to have a purity of 99.99 ± 0.08 percent. Also, thin-layer chromatographic analysis showed no significant amounts of impurities to be present. Microchemical determinations yielded values for carbon, hydrogen, and nitrogen that check the theoretical values of 58.54, 4.09, and 11.38 percent within experimental limits of error.

This new standard is a heterocyclic nitrogen compound which resists analytical decomposition more strongly than acetanilide, formerly supplied as a standard for microdeterminations of nitrogen. It is expected to fill the need which has been expressed for such a standard compound. The large quantity and variety of pharmaceutical products important to the well being of the Nation's population have created a need for a standard reference material typical of these products. Many of these contain a heterocyclic ring, and are analyzed by micromethods on an almost routine basis during research on, manufacturing of, and assaying of pharmaceutical, food, and related products.

NBS Standard No. 148 is sold in units weighing approximately 2 grams.



The microcopy resolution test chart designed and announced in 1963 (left) has been on sale since December 1, 1964. The chart designed and announced in 1967 (right) went on sale December 1, 1967. These charts are for illustration only and should not be used for test purposes.

NEW NBS MICROCOPY RESOLUTION TEST CHARTS HAVE HIGHER FREQUENCIES

Starting December 1, 1967, the microcopy resolution test charts issued by NBS, Standard Reference Material No. 1010, will have higher spatial frequencies than those issued previously. The Bureau announced its intention to extend the range of these charts about a year ago.[1]

The previous type was designed in 1963 and had 21 patterns of black bars on a white background ranging from 1 to 10 cycles/mm. These patterns were arranged to permit the extension of the chart to include higher spatial frequencies.[2] The new type has five additional patterns with spatial frequencies of 11, 12.5, 14, 16, and 18 cycles/mm. In every other respect both charts are identical and may be used for the same purposes.[3]

American industry and Government spend about a third of a billion dollars annually to microfilm records and preserve films. To assure that the microfilmed images are of adequate quality to store the required information, microfilm contracts generally stipulate that the resolving power of the complete microfilming system be evaluated by means of NBS microcopy resolution test charts. The charts are placed in several locations on the camera copy board and are photographed, in the same manner as a document to be recorded. The resulting image is then examined with a microscope. The number of cycles/mm in the smallest pattern in which the bars can be counted with reasonable assurance is the resolving power of the system.

The charts containing these patterns have been produced and issued by NBS for about 26 years, as part of the Bureau's standard reference materials program. The design of the charts and the quality control is the responsibility of the Image Optics and Photography Section. The charts have been produced by the Photographic Services Section of NBS. The number of charts issued annually has been increasing almost continuously, but the demand has soared in recent years. The current volume is about 25,000 charts per year. This large demand will be met in the future by charts procured from private industry but issued by NBS with the same quality control that has been exercised in the past.

Because of the limitations imposed by the methods and materials used in the production of the charts, the 18 cycles/mm pattern does not meet the high quality standards maintained for the 10 cycles/mm pattern. Despite these limitations, the additional spatial frequencies should prove to be of great value to many users, although most systems in use today with probably not resolve them.

The new chart bears the designation 1963-A because it is a minor modification of the 1963 design. All NBS microcopy resolution test charts, regardless of date of issue, satisfy the requirements of all Government specifications for microfilming services. If future specifications should require charts having spatial frequencies above 10 cycles/mm, the new charts will, of course, be required.

The new charts, NBS Standard No. 1010, Microcopy Resolution Test Chart, are sold in units of five for $8.75.[4] Instructions for the use of the charts are supplied with each order.

[1] **Standardization and research at the National Bureau of Standards**, by C. S. McCamy, Appl. Opt. **6**, 28 (Jan. 1967).
[2] **The NBS microcopy resolution test charts**, by B. H. Fouquet, Proceedings of the Twelfth Annual Meeting of the National Microfilm Association, pp. 67–76 (1963).
[3] For a complete list of Standard Reference Materials available from NBS, see **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards**, NBS Misc. Publ. 260, 1967 Edition, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which up-date Misc. Publ. 260 are supplied to users on request.
[4] These standards may be purchased for the price indicated from the Office of Standard Reference Materials. National Bureau of Standards, Washington, D.C. 20234.

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CONFERENCE & PUBLICATION *Briefs*

ATOMIC SPECTROSCOPY SYMPOSIUM HELD AT NBS

The National Bureau of Standards and the U.S. National Research Council Committee on Line Spectra were joint sponsors of a symposium on atomic spectra, September 11 to 14, 1967, at Gaithersburg, Md. Approximately 150 of the world's leading atomic spectroscopists representing many of the major international research centers for atomic spectroscopy were in attendance. A total of 78 invited and contributed papers were given during the four-day meeting.

The principal theme of the symposium was the analysis and interpretation of atomic spectra. A comprehensive summary of present capabilities, and future potentials of the more useful tools for atomic spectra investigations were presented. Emphasis was placed on exchanging knowledge and establishing communication among the various laboratories.

Many aspects of optical atomic spectroscopy were covered during the symposium. Results were given for studies of a variety of atoms and ions using spectra obtained from such sources as infrared lasers, lamps, sparks, synchrotron light, and gaseous atomic beams. New methods of spectra interpretation were described, as were methods of applying computers to analytical calculations.

The delegates were welcomed at the opening of the Symposium by I. C. Schoonover, Deputy Director, NBS. The remainder of the Symposium consisted of 16 sessions, each covering an area of atomic spectroscopy research such as astronomical spectra-plasmas, intensities-profiles, instrumentation-measurements, isotope shifts, theory, Zeeman effect, autoionization, and complex spectra.

FIFTH TRANSDUCER WORKSHOP MEETS AT NBS

Scientists and engineers who use or study transducers—including the small devices used to send electrical signals indicating changes in temperature, pressure, and acceleration—met at the Fifth Transducer Workshop at the Gaithersburg laboratories of the National Bureau of Standards October 3 and 4, 1967. The Workshop was sponsored by NBS and the Transducer Committee of the IRIG (Inter Range Instrumentation Group) Telemetry Working Group, reflecting the interest of both research and application-oriented people. This is apparent also in the makeup of the more than 100 attendees, people who use or study transducers in: Government, both civilian and military; the aerospace industry; educational institutions; and research institutions. This is the fifth such Workshop, following by five years another held at the Bureau's old facilities at Washington, D.C.[1]

The IRIG was formed in March 1952 to exchange information on instrumentation problems common to government testing ranges and to facilitate standardization of instrumentation systems. Its efforts are conducted by working groups; the Transducer Committee of the Telemetry Working Group deals with transducer evaluation, calibration and standardization problems, all of interest to those attending the Workshop. Much of the Workshop's discussion centered on evaluating and selecting transducers and on the expected longevity of operation within tolerance.

The present Workshop was presided over by General Chairman L. L. Lathrop, of the Sandia Corporation. Cochairman P. S. Lederer, of NBS, handled much of the preparation and planning for the meeting, assisted by J. S. Hilten, NBS.

Introductory remarks on NBS and its role in transducer work were given by A. V. Astin, NBS Director, and L. Kushner, Deputy Director of the NBS Institute for Applied Technology. They were followed by M. G. Domsitz, Chief of the Bureau's Electronic Instrumentation Division, who noted that one-tenth of the Bureau's unclassified projects involve transducers. The Bureau uses transducers, he said, to measure fixed constants, to better measure standards, to improve calibration techniques, and to explore properties of matter and materials. J. Stern, Chief of the Bureau's Basic Instrumentation Section, noted that "basic" research on transducers can be regarded as being both fundamental and applied. His group prefers projects which have broad implications and are not constrained to produce information of narrow applicability.

In the following technical session, under the chairmanship of W. G. James of the Air Force, J. S. Hilten gave a progress report on the NBS Inter Agency Transducer Proj-

ec . in which the Bureau renders specific-goal services for the Air Force, the National Aeronautics and Space Administration, and the U.S. Navy. He described the types of accelerometer and pressure transducer calibrations performed at NBS and special devices developed for this purpose, with emphasis on the earth's field dynamic calibrator now under evaluation. Following this, A. H. Boyd of the Air Force Rocket Propulsion Laboratory described advances in pulse flow measurement by means of instrumentation making use of the change in velocity of laser light passing through a moving medium—one of the varied applications in which lasers have been found to be useful. The transducer development program at the Air Force Special Weapons Center was described by H. M. Fernandez. The part played by transducers in making pressure measurements in a hypersonic wind tunnel was detailed by F. B. Kroeger of Ohio State University. This session was concluded with a description of various techniques for making multiple pressure measurements in wind tunnels, given by E. K. Yager of General Dynamics/Convair.

Transducers in measurement systems were discussed in the next session by a panel presided over by P. S. Lederer. R. D. Bronson of General Dynamics/Convair first gave criteria for the selection and use of transducers, L. Horn of NBS noted the importance of their design and construction features, J. A. Harmon of the White Sands Missile Range discussed their evaluation and calibration, and H. W. Rosenberg of the China Lake Naval Ordnance Test Station discussed interpretation of data. The views expressed by the panelists on the need for transducer calibrations, in addition to those of the manufacturer, evoked considerable discussion by other attendees on both procurement and subsequent calibrations.

The following technical session, presided over by A. H. Boyd, was opened with a description of transducer sensing with readouts in the time domain, by H. G. Tobin and J. N. Scoyoc of IIT Research Institute. This was followed by papers on the cross-axis sensitivity of piezoelectric accelerometers, by R. E. Harper of Pratt and Whitney, and on the evaluation of bonded strain gage pressure, force, and flow transducers, by R. T. Cusick of the Johns Hopkins University Applied Physics Laboratory. This session was concluded with two papers on transducer problems, one on precautions to be observed in the use of transducers and the usefulness of input conditioning, by P. Stein of Arizona State University, and one on the unique transducer problems encountered in operating a supersonic test track, by G. A. Price of the Air Force.

During a tour of NBS laboratories engaged in transducer research, the attendees inspected the Bureau's deadweight pressure calibration facilities, the shaker development and accelerometer calibration laboratory, the pressure measurements research laboratories, and the laboratory of the interagency transducer project.

Persons, in addition to attendees of the Workshop, interested in obtaining a copy of the *Proceedings* should write to: The Secretariat, Range Commander's Council, White Sands Missile Range, N. Mex. 88002.

SIXTH CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS

The 1968 Conference on Precision Electromagnetic Measurements will be held June 25 to 28, at the Boulder Laboratories of the National Bureau of Standards, Boulder, Colo. This meeting will be the sixth in the biennial series begun in 1958. The Conference is sponsored by the NBS Institute for Basic Standards, the Group on Instrumentation and Measurement of the Institute of Electrical and Electronics Engineers, and the U.S. Commission 1 of the International Scientific Radio Union (URSI). The Bureau of Continuation Education of the University of Colorado will handle the local arrangements.

The aim of the Conference is the advancement of electromagnetic measurements at levels of precision and accuracy appropriate to national standards laboratories. The traditional fields of DC, LF, HF, and microwave measurements together with related physical studies provide the core of the Conference subject matter. In this year's Conference, emphasis will be placed on the rapidly developing field of automated precision measurements. Methods for precise pulse and waveform measurements will also receive special attention.

As in the past, the Conference encourages international participation. In recognition of the importance of this aspect, a special session will be devoted to the international comparison of standards.

A call for papers is issued in the following areas: direct current and low-frequency measurements, time and frequency, radio frequency and microwave measurements (including coherent optical techniques), pulse and modulation measurement, and automated measurements. Six copies each of a summary and abstract should be included. The summary of 500–1000 words may include up to five illustrations and will be reproduced in the program digest. The abstract should contain no more than 200 words and no illustrations. Deadline for receipt of abstracts and summaries is February 12, 1968. They should be submitted to:

Donald D. King
Aerospace Corporation
P.O. Box 95085
Los Angeles, Calif. 90045

Papers given at the Conference will be published in a Special Issue of the *IEEE Transactions on Instrumentation and Measurement.*

Further information concerning the Conference may be obtained from:

George Goulette
Bureau of Continuation Education
328 University Memorial Center
University of Colorado
Boulder, Colo. 80302

continued on page 273

STANDARDS AND CALIBRATION

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustments made on January 1, 1968.* The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on January 1, 1968.*

WWV DAY—1967

The new location and new facilities of NBS radio station WWV at Ft. Collins, Colo., which began its transmissions last December,[1] were the themes of a special program at Ft. Collins on July 29, 1967. J. M. Richardson, chief of the NBS Radio Standards Laboratory which operates the station, was master of ceremonies of the program which featured an address by Hon. Gordon Allot, U.S. Senator from Colorado. An Open House was held at which guests could inspect the new facilities.

It was back in March 1923 that the National Bureau of Standards first started transmitting standard radio frequencies on a regularly announced schedule from radio station WWV. Since then WWV has expanded its schedules and services and is today making major contributions to the Nation's space and defense programs, to worldwide transportation and communications, and to the broadcast and electronics industries.

WWV broadcasts eight services: [2] standard radio frequencies (2.5, 5, 10, 15, 20, and 25 MHz), standard audio frequencies (1000, 600, and 440 Hz), time intervals (the second, minute, and hour), time identification by voice, universal time UT2 in international Morse code, daily corrections to UT2, forecasts of radio propagation conditions, and geophysical alerts.

The WWV transmitter was originally located at the National Bureau of Standards in Washington, D.C., and it remained there until 1931. Since then it has moved successively to College Park, Beltsville, and Greenbelt (all Maryland suburbs of Washington), and finally, in 1966, to Ft. Collins, Colo., where it went on the air at 0000 hours GMT, December 1, 1966.

The move to Ft. Collins was prompted by rapidly obsolescing equipment, the need for a more geographically central location, the high ground-conductivity at Ft. Collins, relative freedom from interference by industry, and proximity to the NBS atomic frequency standards at Boulder, Colo.

In 1923, broadcasts by WWV were only accurate to within a few parts in a thousand. Accuracy today is on the order of a few parts in a million million (10^{12})—almost as good as the NBS atomic frequency standard itself.

ELECTRON-BEAM MEASUREMENTS PROGRAM

Recent improvements in the production, detection, and utilization of high-energy electrons have opened the way for striking advances in the scale and kinds of electron-beam applications. Effective control of the beams depends critically on accurate measurements, and these depend in turn on reliable measurement techniques and on stable, precise standards. To provide such techniques and standards is the goal of a large effort now under way at Gaithersburg, Md., in the NBS Institute for Basic Standards.[3]

At present the Institute provides accurate and uniform techniques of physical measurement in several areas of radiation science. It investigates, develops, and improves radiation sources and standards; supplies calibration services for standard measuring instruments, materials, foils, fields, and sources; and advises other Government agencies on radiation measurements. The Institute's services, existing [4] or under development, for standard instruments and sources, are listed in Table 1.

Table 1. Services of the National Bureau of Standards in measurements of radiation

Radiation	Service	
	Present	Possible future
A. X rays 1. 10 kV–3 MV	(a) Cavity-chamber calibration in roentgens	(a) Same (b) Calibrations in joules per square centimeter
2. 3 MeV–180 MeV	(a) Transmission-chamber calibrations in joules	(a) Same
B. Alpha rays Beta rays Gamma rays	(a) Radioactivity standards and source calibrations in microcuries (b) Source calibrations in roentgens per hour at 1 meter	(a) Same (b) Same (c) Source calibrations in watts per square centimeter at 1 meter
C. Electron beams	(a) None	(a) Faraday-cage calibrations of transmission monitors in amperes (b) Absorbed-dose calibrations under special radiation conditions and irradiation geometries
D. Neutrons	(a) Neutron-source standards in neutrons per second (b) Neutron-source calibrations in neutrons per second (c) Foil calibrations in thermal neutron-flux facility in neutrons per square centimeter second	(a) Same with larger variety of radioactive sources (b) Same with larger variety of radioactive sources (c) Same with larger fluxes; with reactor standard fluxes (d) Monoenergetic radioactive neutron-source standards (e) Monoenergetic accelerator neutron calibrations

Table 2. Characteristics of the new NBS accelerators; pps, pulses per second; d-c, direct current.

Accelerator	Energy (MeV)	Current (mA)	Power (kW)	Dimensions (diameter × length; m)	Beam diam. (mm)	Pulse length (μsec)	Repetition rate (pps)
Linac	80	1	80	0.5×30.5	3	0.01–6.0	≤720
Van de Graaff	4	1	4	2 × 8.2	10	1 (or d-c)	≤500
Dynamitron	1.5	10	15	1.2× 7	2	(d-c)	(d-c)

Measurement services are already being offered in the Institute for radiation fields of x rays, alpha, beta, and gamma rays, and neutrons, but there are none at present for high-energy electron beams. However, the rate of advance in electron-beam technology has called forth a correspondingly substantial effort by NBS to provide accurate measurements. Work in all these radiation fields is the function of a specialized laboratory now ready to broaden its services.

Among the larger pieces of equipment of this laboratory are x-ray machines and electron accelerators operating in the 10-keV to 200-MeV radiation-energy range. Characteristics of its three most intense electron sources are summarized in Table 2. Single devices comparable to these can be found in the larger industrial, university, or Government laboratories. However, the particular combination of facilities and the special attention given to stability of operation and accuracy of measurement uniquely equip the new laboratory for its task of developing electron-beam standards.

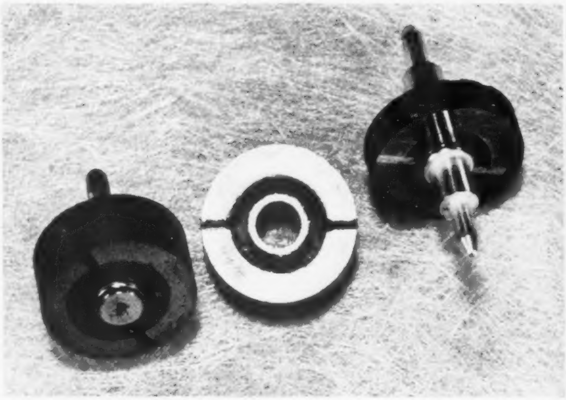
[1] See **Construction of new WWV buildings begun**, NBS Tech. News Bull. **51**, 161 (Sept. 1966) and **WWV to send first day QSL cards**, NBS Tech. News Bull. **51**, 211 (Nov. 1966).

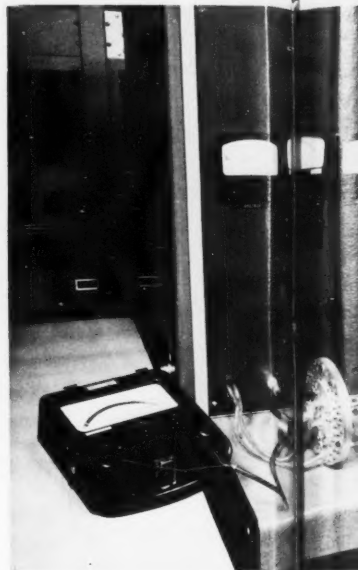
[2] For a description of these services, see **NBS Standard Frequency and Time Services**, NBS Misc. Publ. 236, 1967 Edition, available at 15 cents per copy from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[3] For further details, see **Electron beams: National Bureau of Standards and the new technology**, by H. W. Koch, Science **156**, 321–328 (Apr. 1967).

[4] Descriptions, conditions, fees, and instructions for obtaining NBS measurement services and standard materials are given in NBS Misc. Publ. 250, **Calibration and Test Services** ($1.00 per copy) and NBS Misc. Publ. 260, **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards** (45 cents per copy), both for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The heart of the Bolovac is a resistive film patterned in two semicircular areas. The film is deposited on an insulating disk, which is mounted in the bolometer head, with the center conductor passing through it.





M. C. Selby holds the bolometric voltage and current standard (Bolovac) he developed.

THE BOL

Voltage and Current Masu

■ To meet the advancing needs of science and technology, the NBS Institute for Basic Standards must strive constantly to improve the accuracy of its calibration services. In the field of radio standards it must also continually extend the range of frequencies over which it provides services.

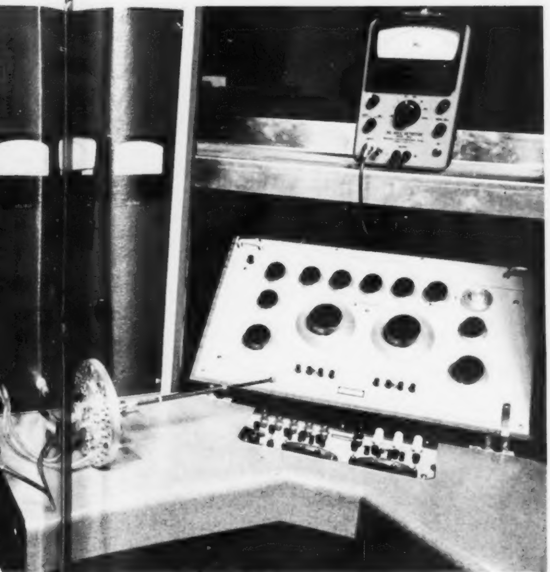
Radiofrequency voltage standards developed by NBS in the 1950's were useful up to about 1 GHz (1000 Mc). The upper limit of frequencies used has gradually risen and recent needs have led M. C. Selby, of the Institute's Radio Standards Laboratory at Boulder, Colo., to develop an instrument, called a Bolovac, for measuring voltage and current at frequencies up to 20 GHz. Because of its accuracy, simplicity, and ease of use, the Bolovac is now the standard with which voltage- and current-measuring instruments sent to the Laboratory for standardization are compared in the 1–10 GHz region.[1]

Measurements at Gigahertz Frequencies

Measuring radiofrequency parameters at gigahertz (kilomegacycle) frequencies presents inherent problems. At such frequencies the wavelength approaches the dimensions of electrical paths within the measuring instrument, and care must be taken to prevent the measurement from changing the system being measured.

Bolometric methods of measurement are used in the gigahertz range primarily for measuring power. Bolometry makes use of the fact that most materials are heated if they absorb rf energy, and thus undergo a change in resistance. In the substitution bolometry method a bolometer element positioned across an rf transmission path is first heated to a reference resistance value (measured by a resistance bridge) by passing a controlled bias current (d-c or audio-frequency) through it. When it is subjected to an rf field, the amount by which the biasing must be reduced to produce the same resistance value is equated with the rf power absorbed; from this the total rf voltage or current can be computed.

Bolometric devices used [2] include the barretter (a fine resistance wire) and the thermistor (a tiny piece of semiconductive material bridging its two leads). The impedance of these devices changes not only with heat, but also



Using the Bolovac, a thermoelement is standardized at 1 GHz. Rf energy from the console passes through the Bolovac (disk in foreground) to the thermoelement mounted directly on one of the Bolovac's coaxial connectors.

BOLOVAC

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with frequency; they have nearly reached the limit of their usefulness at 1 GHz. Needed were devices for testing and standardizing that are insensitive to frequency changes between 1 and 10 GHz or higher frequencies.

The Bolovac

The Bolovac—so called for "*bolo*metric *v*oltage *a*nd *c*urrent"—standard is a bolometric "head" which is connected in a coaxial transmission line between the radiofrequency source and the load to measure the rf voltage. The same voltage-measuring instrument or a variant of it is used for measuring rf current. It is the most practical instrument to date for standardizing high-frequency currents of 5 to 1000 milliamperes.

The power-sensitive unit of the bolometer is a conductive film, in the shape of two half-disks, deposited on an insulating disk, through which the center coaxial conductor runs. The greater the rf power flowing through the device, the more power is absorbed by the two film areas, the hotter they become, and the more their resistance increases. The bolometer head is so designed that the two half-disks are connected in parallel for the rf power and in series for the biasing power—an easily controlled audiofrequency or d-c source.

The Bolovac is designed to minimize errors resulting from uncertainty of the location of the rf voltage and current planes in the system; the standardizing rf voltage appears essentially at the input plane of the device being calibrated. For ammeter calibrations, the plane through which the rf standardizing current flows is located essentially at the output plane of the current-indicating device being calibrated. The actual separation of planes is of the order of millionths of an inch; the thickness of the dielectric separates biasing from rf input potentials.

The Bolovac disks generally have positive temperature coefficients of resistivity, as against generally negative ones for thermistors. This eliminates the danger of overloading the bolometers in the absence of current-limiting impedances in the biasing and rf sources. Because the rf impedance of each disk is essentially equal to its d-c resistance over a wide frequency range, the Bolovac assembly can be used for some pulsed voltage and current measurements without loss of accuracy.

Another advantage of the Bolovac, in comparison with other devices, is that it measures microwave power transmitted down a uniform line with potentially greater accuracy than most calorimetric techniques. Also, since the Bolovac-disk d-c and rf impedances are essentially the same, its sections can be matched by use of direct current only. This eliminates the tedious and expensive rf matching procedure required with the usual bolometer head. The Bolovac is free of errors associated with single-thermistor mounts and, unlike other instruments, requires no stubs or discrete biasing isolation components.

Fabrication of the Bolovac is relatively simple and the device is more rugged and reliable than the thermistor mounts. It is simple to maintain and requires no special precautions in use, as contrasted with the nonvibrating supports required by dynamometer type instruments and the fragility of thermistor beads and leads.

The Bolovac can be used with a number of types of commercially available bolometer bridges and d-c and low-frequency instrumentation. It is simple and rugged enough to be designed into other assemblies, such as into antennas to make current measurements.

[1] **Voltage measurements at high and microwave frequencies in coaxial systems**, by M. C. Selby, Proc. IEEE **55**, 877–882 (June 1967).

[2] The state of the bolometric art at 1950 and descriptions of bolometric devices are given in: **A bolometer bridge for standardizing radio-frequency voltmeters**, by M. C. Selby and L. F. Behrent, J. Res. NBS **44**, 15–30 (Jan. 1950).

CLEARINGHOUSE
FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION

NEW DOCUMENT ANNOUNCEMENT EXPERIMENT

The Clearinghouse is experimenting with a new medium for announcing Government-generated research and development reports. This new mechanism, referred to as sub-journals, is in the form of one or more sheets listing available reports by 65 subject areas. These subjects were compiled from the standard fields and groups established by the Committee on Scientific and Technical Information (COSATI). COSATI is composed primarily of officials from Federal agencies responsible for scientific and technical information programs. The sub-journal concept permits rapid scanning of reports for bibliographic information in one or more selected areas of interest. The number of reports announced in each category will vary depending upon the number of new documents acquired by the Clearinghouse but should average between 5 and 30 reports every 2 weeks.

The experiment, cosponsored by the Office of Aerospace Research, U.S. Air Force, and the Clearinghouse, will last approximately six months. If, at the end of that time, the results indicate that the sub-journal is a useful item it will be made a regular service of the Clearinghouse in early 1968.

TECHNICAL TRANSLATIONS JOURNAL DISCONTINUED

The *Technical Translations* (TT) announcement journal published by the Clearinghouse will be discontinued after December 1967 (Vol. 18, No. 12, December 30, 1967). Beginning in 1968, all U.S. Government-sponsored technical translations will be announced in the Clearinghouse announcement journal, *U.S. Government Research & Development Reports* (USGRDR). The first issue of USGRDR announcing these translations will be Vol. 68, No. 1, January 10, 1968.

After December 30, 1967, translations not sponsored by U.S. Government agencies will not be announced by the Clearinghouse. These translations are now announced in both the *Translations Register-Index,* published by the Special Libraries Association Translations Center, and in the *ETC Quarterly Index,* published by the European Translations Centre. The Clearinghouse will continue to provide reference information and attempt to answer specific queries on all translations, both Government-sponsored and non-Government-sponsored.

The inclusion of Government-sponsored technical translations in USGRDR makes it a more comprehensive announcement journal covering U.S. Government-sponsored research and development reports and translations. The USGRDR is published on the 10th and 25th of each month. All reports and translations announced in it are indexed in the concurrently issued companion journal, *Government-Wide Index to Federal Research & Development Reports* (GWI). GWI indexes the USGRDR entries by subject, author, source, report number, and contract number. Both of these journals are sold by the Clearinghouse.*

*For subscription information, see Clearinghouse Bibliographic Journals, page 279.

PHASEMETER *continued*

ignored along with certain harmonics. The single triggering mode does not ignore direct current offset or any out-of-phase harmonics, and the output may become spurious in the presence of moderate amounts of noise, particularly at the lower frequencies. Since all zero crossings are effective in the double triggering mode, spurious outputs from noise are absent in this mode. The positions of the zero crossings may be disturbed because of noise, but corresponding errors should average to zero if the measurement is taken over a sufficient number of cycles.

It is expected that an accuracy within 0.01 degree in phase measurement is the best that can be obtained at this time with any phasemeter. This accuracy is limited not by available techniques, but rather by the quality of the signals available to be evaluated.

[1] For a list of manufacturers of logic modules, consult the current Electronic Engineers Master Catalog, United Technical Publications, Inc., New York, N.Y. (annual periodic publications).

[2] Digitized low-frequency phasemeter assembled from logic modules, by J. E. McKinney, J. Res. NBS 71C (Engr. and Instr.) No. 3, 227–238 (July–Sept. 1967).

EXCHANGE OF COMPUTER PROGRAMS AND DOCUMENTATION

The National Bureau of Standards has announced its sponsorship of a survey of services for the exchange of computer programs and program documentation. The survey is being conducted for the Technical Information Exchange of the Bureau's Center for Computer Sciences and Technology.

The first phase of the survey will involve interviews with a number of organizations which exchange, lease, or sell programs and documentation. These include computer-centered and industry-centered users groups, government agencies and their contractors, universities and non-profit corporations, private corporations which distribute primarily internally, and commercial corporations which deal in programs, documentation, or indexes.

The survey will determine the general nature of services offered, the number and types of computer programs involved, and the extent to which program catalogs exist. One of the results of the survey will be a published roster of program exchange organizations of the types just described. Any organization which would like to be listed in this roster should contact the Technical Information Exchange.

A second phase of the survey will include interviews with a cross section of computer users concerning the usefulness to them of a master catalog of all computer programs and documentation available, giving the source of each. Organizations which are interested in such a catalog, or which now publish program catalogs or indexes also, are invited to contact the Technical Information Exchange. The address is:

Technical Information Exchange,
B250-Instr.
Center for Computer Sciences and Technology
National Bureau of Standards
Washington, D.C. 20234

BRIEFS *continued*

HANDBOOK OF INDUSTRIAL METROLOGY

A *Handbook of Industrial Metrology*, described in its subtitle as "a reference book on principles, techniques, and instrumentation design and application for physical measurements in the manufacturing industries," has been issued by the American Society of Tool and Manufacturing Engineers (ASTME) assisted by experts from industry, the universities, and the National Bureau of Standards. The level of treatment is intended to be within the scope of the average engineer's comprehension.[2]

Plans for the book first took shape in 1964 at a meeting between representatives of ASTME, faculty members of George Washington University (believed at the time to be the only American graduate school with a full metrology course), and I. H. Fullmer and A. G. McNish of the NBS Institute for Basic Standards. Under the policy supervision of the ASTME Publications Committee, the text was written by a panel of 25 contributors from industry, the universities, and NBS. Contributors from NBS were H. H. Ku of the Statistical Engineering Laboratory and three members of the Metrology Division staff: A. G. McNish, Chief of the Division; T. R. Young, Chief of the Length Section; and C. S. Kopec of the Engineering Metrology Section.

Four chapters of a general character first lay a groundwork. They define the nature of metrology, present basic principles, and give an account of the standards and statistical concepts around which metrology centers. Then come eleven chapters on more concrete topics: direct measuring tools and instruments (e.g., gage blocks), optical projectors, pneumatic comparators, electric and electronic gages, interferometers and associated devices, comparative measurements by ultrasonic and radiological techniques, geometric considerations in linear measurements, optical alinement, surface texture, screw threads, and gears. Emphasis is on proper and efficient application of devices and techniques; details of manipulation are left to suppliers' instruction manuals. The last chapter, on the management of inspection and quality control, is concerned with the functioning of organizational policy to interrelate soundly and utilize fully the measurement capabilities in a plant.

[1] **Transducer group meets at NBS**, NBS Tech. News Bull. **46**, 162 (Nov. 1962).

[2] The **Handbook** has 445 pages, 29 tables, about 280 illustrations, and index. Publisher: Prentice-Hall Inc., Englewood Cliffs, N.J. Price: $15.

NATIONAL STANDARD REFERENCE DATA SYSTEM

NSRDS NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data, located in the Administration Building at the NBS Gaithersburg Laboratories.

A Program Package for Computer-Assisted Text Editing and Data Retrieval

A major problem in the extension of computer techniques to the processing of scientific manuscripts—either for editing and automatic typesetting or for storage and retrieval—is the limited number of characters on the ordinary computer printer, card punch, and typewriter. The problem is not insurmountable and has been met with varying success.

Recent developments in hardware and programming should soon provide a capability to handle text with scientific notations, such as subscripts, superscripts, Greek letters, mathematical and logic symbols, and diacritical marks present in some languages.

It is not economical, nor even necessary, for computer printers to provide authors with the nearly 1,000 symbols available to printers who specialize in scientific publications. A computer line-printer component with 240 distinct characters and having provision for half-line spacings offers enough flexibility to cope with all but the most specialized situations.

Early in 1968, the Office of Standard Reference Data will have access to such a computer. This line-printer will have 240 distinct characters, will be able to provide half-line spacing for subscripts and superscripts, and will be able to print several characters in the same position (e.g., / imposed over 0 gives ∅).

Computers can accomplish easily and efficiently a variety of tasks encountered in editing, printing, and revising data compilations. They can modify or refine text (delete unwanted information or instructions); select, abridge, or rearrange lines or blocks of data or text; format the final printed pages; and, finally, build a table of contents and an index.

A number of text editing programs for these purposes now exist, and others are being developed.[1-3] Not only can "editing" problems be solved, but they can be solved in such a way as to produce simultaneously a general-purpose data retrieval system of considerable power and flexibility.

A suitably designed editing progran serves still another important purpose—that of providing a simple means of coping with different data formats. Such a program makes the transformation of data or text files from one format to another a trivial task, and thereby reduces the necessity to force heterogeneous files into rigid formats.

A package of utility programs for computer-assisted editing (Edpac) with the above-mentioned characteristics and objectives is being developed by the Office of Standard Reference Data in collaboration with some of its associated data centers at NBS. The first computer programs of this series will be described in a forthcoming NBS publication.[4]

The first release of Edpac contains FORTRAN program listings and descriptions of five programs: JUSTIFY, SCRAMBLE, SEARCH, BLOCKSEARCH, and SUBSTITUTE. These may be used independently or in sequence.

Any editing system which permits the deletion or addition of substantial segments of text must have some provision for rearranging the words into lines of specified length. JUSTIFY is a text formatting program which provides this facility with or without justified righthand margins. It can center lines of text, indent, and perform other features useful in preparing camera-ready copy. However, the program does not hyphenate words at the end of a line. When line justification is called for, the extra spaces are placed first after each period in the line and then between the words, starting from the left in one line and from the right in the next. Because simplicity of use is an important factor in the design of these programs, the rules are kept as conventional as possible. For ex-

ample, the start of a paragraph is ordinarily signaled by leaving at least one blank space at the beginning of the line—just as a typist might indent when starting a new paragraph—or by inserting a blank card which is equivalent to leaving a blank line when paragraphs are not indented.

SCRAMBLE provides for the substitution of any single character for any other. It is equivalent to a simple substitution cipher. It is used in the transformation of variables, in the conversion of one precedence symbol to another, and in character transformations in linguistics research.

The program called SUBSTITUTE is a more versatile and correspondingly more complex program. It has a provision for replacing any character string by any other character string regardless of where it occurs in the text. Among the diverse jobs this program can do are the following:

a. Convert text punched on cards in BCD format (all capital letters) to upper and lower case, such as initial capitalization of the start of each sentence and authors' names and initials.
b. Replace any arbitrary set of symbols by corresponding instructions for a phototypesetting machine.
c. Recognize typesetting instructions in a text and either delete them or replace them with other codes.
d. Anglicize text written by Americans.
e. Replace journal abbreviations by their five letter CODEN designations or vice versa, or by the full title.
f. Match citation numbers in the body of a paper with an indexed list of references.
g. Insert complex mathematical expressions when they occur frequently in a text, thereby avoiding needless retyping and subsequent proofreading.
h. Insert typesetting instructions in place of code words for special symbols not available on the input device.
i. Screen and correct automatically inconsistent use of abbreviations or symbols.

SEARCH and BLOCKSEARCH are useful for data retrieval. The first program searches a card image of a single line of text for the presence of *any* or *all* of a group of words or strings or fragments; it prints out the line or punches out a card when such items are located.

BLOCKSEARCH is able to scan an entire block of lines, making it generally more useful in data retrieval. This search is made not on a single line but on a suitably delineated block, such as a paragraph, a page, a full bibliographic citation, or an abstract. On a successful match the entire block is printed or punched.

An important feature of both searching programs is the ability to handle fragments such as prefixes or suffixes or even fragments in the interior of words. Ordinarily the scanning is anchored to the beginning of the word. For example, asking for the word "thermo" would produce lines with thermodynamics, Thermodynamics, thermochemistry, and Thermochemistry. If the program is set to the unanchored mode, it will locate the word Aerothermo-(Δ) at the end of a string of restricts the search to endings dynamics as well. In this search mode, imbedding a blank or suffixes. Thus, when asked to located FLEX$^{\Delta}$, the program will find CELLUFLEX, but not FLEXIBLE. Set to locate all lines containing both of the strings ΔCEL and LEXΔ, this program would locate all words beginning with CEL and ending with LEX, such as CELLS and COMPLEX.

The Edpac programs have been written in FORTRAN with considerable care to avoid any machine-dependent instructions so as to permit the direct use with the various computers utilized by the NBS data centers. The programs run without modification on the IBM 7094, the CDC 3600, the UNIVAC 1107 and 1108, and the IBM 360/30.

Subsequent *NSRDS News* articles will discuss programs for more sophisticated Boolean search strategies, conventions for keyboarding an extended character set, and programs for converting computer tapes to feed photo- and electronic-typesetting machines.

Bibliography of Atomic and Molecular Processes

Bibliography of Atomic and Molecular Processes for July–December 1965, compiled by the the Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, is the fourth of a series.[6] This annotated bibliography contains references of interest to atomic and molecular processes research. Bibliographical sources consisted of seventy-eight scientific journals and five abstract journals. The references are classified into fourteen major categories with appropriate subcategories. Each entry in the respective category is entered alphabetically and includes the reactants on the atomic and molecular system of interest. The bibliography is available from the Atomic and Molecular Processes Information Center.

NSRDS Publication Summary

A. Publications Issued in the NSRDS Series:

1. NSRDS—Plan of Operation, by E. L. Brady and M. B. Wallenstein, NSRDS-NBS-1 (15 cents).[5]

2. Thermal Properties of Aqueous Uni-univalent Electrolytes, by V. B. Parker, NSRDS-NBS-2 (45 cents).[5]

3. Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables, Si II, Si III, Si IV, by C. E. Moore, NSRDS-NBS-3 (35 cents).[5]

4. Atomic Transition Probabilities, Volume I, Hydrogen Through Neon, by W. L. Wiese, M. W. Smith, and B. M. Glennon, NSRDS-NBS-4 ($2.50).[5]

5. The Band Spectrum of Carbon Monoxide, by P. H. Krupenie, NSRDS-NBS-5 (70 cents).[5]

6. Tables of Molecular Vibrational Frequencies, Part 1, by T. Shimanouchi, NSRDS-NBS-6 (40 cents).[5]

7. High Temperature Properties and Decomposition of Inorganic Salts, Part I, Sulfates, by K. H. Stern and E. L. Weise, NSRDS-NBS-7 (35 cents).[5]

continued

8. Thermal Conductivity of Selected Materials, by R. W. Powell, C. Y. Ho, and P. E. Liley, Thermophysical Research Center, Purdue University, NSRDS–NBS–8 ($1).[5]

9. Bimolecular Gas Phase Reactions, by G. S. Milne and A. F. Trotman-Dickenson, NSRDS–NBS–9.[6]

10. Selected Values of Electric Dipole Moments for Molecules in the Gas Phase, by R. D. Nelson, Jr., D. R. Lide, Jr., and A. A. Maryott, NSRDS–NBS–10 (40 cents).[5]

11. Tables of Molecular Vibrational Frequencies, Part 2, by T. Shimanouchi, NSRDS–NBS–11 (30 cents).[5]

12. Hydrogenation of Ethylene on Metallic Catalysts, by J. Horiuti, NSRDS–NBS–13.[6]

13. X-Ray Wavelengths and X-Ray Atomic Energy Levels, by J. A. Bearden, NSRDS–NBS–14 (40 cents).[5]

14. Molten Salts: Electrical Conductance, Density, and Viscosity Data, by G. J. Janz, F. W. Dampier, and P. K. Lorenz, NSRDS–NBS–15.[6]

15. Thermal Conductity of Selected Materials, Part 2, by C. Y. Ho, R. W. Powell, and P. E. Liley, NSRDS–NBS–16.[6]

16. Tables of Molecular Vibrational Frequencies, Part 3, by T. Shimanouchi, NSRDS–NBS–17.[6]

17. Critical Analysis of the Heat-Capacity Data of the Literature and Evaluation of Thermodynamic Properties of Copper, Silver, and Gold from 0 to 300 °K, by G. T. Furukawa, W. G. Saba, and M. L. Reilly, NSRDS–NBS—18.[6]

18. Selected Tables of Atomic Spectra, A. Atomic Energy Levels—Second Edition, B. Multiplet Tables, Si I, Data Derived From the Analysis of Optical Spectra, by C. E. Moore, NSRDS–NBS–3, Section 2.[6]

19. Critical Evaluation of Ion Appearance Potentials, Ionization Potentials and Ion Heats of Formation, by J. L. Franklin, F. H. Field, J. Dillard, H. M. Rosenstock, and F. N. Harllee.[6]

20. Tables for the Rigid Asymmetric Rotor: Transformation Coefficient From Symmetric to Asymmetric Bases and Expectation Values of P^2_z and P^4_z, by R. H. Schwendeman and V. W. Laurie.[6]

B. Other NBS Compilations of Data:

1. Selected Values of Chemical Thermodynamic Properties, Part 1, Tables for the First Twenty-Three Elements in the Standard Order of Arrangement, by D. D. Wagman, W. H. Evans, I. Halow, V. B. Parker, S. M. Bailey, and R. H. Schumm, NBS Tech. Note 270–1 (65 cents).[5]

2. Selected Values of Chemical Thermodynamic Properties, Part 2, Tables for the Elements Twenty-Three Through Thirty-Two in the Standard Order of Arrangement, by D. D. Wagman, W. H. Evans, I. Halow, V. B. Parker, S. M. Bailey, and R. H. Schumm, NBS Tech. Note 270–2 (40 cents).[5]

3. Electron Impact Ionization Cross-Section Data for Atoms, Atomic Ions, and Diatomic Molecules: I. Experimental Data, by L. J. Kieffer and G. H. Dunn, published in *Reviews of Modern Physics* **38,** No. 1–35 (January 1966).[7] Also to be bound with related material in the NSRDS series.

4. Superconductive Materials and Some of Their Properties, by B. W. Roberts, NBS Tech. Note 408 (45 cents).[5]

5. Microwave Spectral Tables, Diatomic Molecules, by P. F. Wacker, M. Mizushima, J. D. Petersen, and J. R. Ballard, NBS Mono. 70, Vol. I ($2).[5]

6. Microwave Spectral Tables, Line Strengths of Asymmetric Rotors, by P. F. Wacker and M. R. Pratto, NBS Mono. 70, Vol. II ($3).[5]

7. Microwave Spectral Tables, NBS Mono. 70, Vols. III, IV, and V.[6]

8. Thermodynamics and Related Properties of Parahydrogen from the Triple Point to 100 °K at Pressures to 340 Atmospheres, by H. M. Roder, L. A. Weber, and R. D. Goodwin, NBS Mono. 94 (75 cents).[5]

9. Critical Review of Cross-Sections for Electron Excitation of Atoms by Electron Impact, by B. Moiseiwitch (to be published in *Reviews of Modern Physics,* January 1968).

10. Electron Impact Ionization Cross-Section Data for Atoms, Atomic Ions, and Diatomic Molecules: II. Theory and Comparison of Theory and Experiment, by M. Rudge, L. J. Kieffer, and G. H. Dunn (to be published in *Reviews of Modern Physics,* January 1968).

11. Compendium of *ab-initio* Calculations of Molecular Energies and Properties, by M. Krauss.[6]

C. Nondata Publications from NSRDS Related Projects:

1. Bibliography on Atomic Transition Probabilities, by B. M. Glennon and W. L. Wiese, NBS Misc. Publ. 278 (55 cents).[5]

2. Bibliography of Low Energy Electron Collision Cross-Section Data, by L. J. Kieffer, NBS Misc. Publ. 289 (50 cents).[5]

3. Bibliography of Atomic and Molecular Processes for 1963, by C. F. Barnett, J. A. Ray, J. C. Thompson, and E. W. McDaniel, ORNL–AMPIC–1 (July 1965).[8]

4. Bibliography of Atomic and Molecular Processes for 1964, by C. F. Barnett, D. A. Griffin, M. O. Krause, J. A. Ray, J. W. Hooper, D. W. Martin, E. W. McDaniel, and E. N. Thomas, ORNL–AMPIC–3 (Mar. 1966).[8]

5. Directory of International Workers in the Field of Atomic and Molecular Collisions, September 1965, ORNL–AMPIC–2 (Oct. 1965).[8]

6. Automated Computer Tape Program for Estimation of Physical Properties of Materials for which no Measurements Exist (available from the American Institute of Chemical Engineers, 345 East 47th Street, New York, N.Y.).

7. Photonuclear Data Index, prepared by Photonuclear Data Group, NBS Radiation Physics Division, NBS Misc. Publ. 277 (55 cents).[5]

8. Status Report—National Standard Reference Data System, April 1966, NBS Tech. Note 289 (50 cents).[5]

9. Information Handling in the National Standard Reference Data System, by F. L. Alt, NBS Tech. Note 290 (25 cents).[5]

10. Bibliography of Flame Spectroscopy, Analytical Applications, 1800 to 1966, by R. Mavrodineanu, NBS Misc. Publ. 281 ($2).[5]

11. A Bibliography on Ion-Molecule Reactions, January 1900 to March 1966, by F. N. Harllee, H. M. Rosenstock, and J. T. Herron, NBS Tech. Note 291 (30 cents).[5]

12. Coblentz Society Specifications for Evaluation of Infrared Reference Spectra, by Board of Managers, Coblentz Society, *Analytical Chemistry* **38,** No. 9 (Aug. 1966) (available from the Office of Standard Reference Data or Coblentz Society).

13. Bibliography of Atomic and Molecular Processes for July–December 1965, compiled by Atomic and Molecular Processes Information Center, ORNL–AMPIC–6 (Sept. 1967).[8]

[1] **Text 90,** by J. C. Sekora, International Business Machines Corp., Dept. D78, Poughkeepsie, N.Y. (June 10, 1965).

[2] **FORMAT, a text processing program,** by G. M. Berns, IBM Washington Scientific Center, 11141 Georgia Ave., Wheaton, Md. 20902 (July 1967).

[3] **Computer-assisted text preparation,** by J. Hilsenrath and K. Waibel, Technical Report TR-67-47, Computer Science Center, University of Maryland, College Park, Md. 20742 (July 1967).

[4] **Edpac: Utility programs for computer-assisted editing, copy-production, and data retrieval,** by C. G. Messina and J. Hilsenrath, to be published.

[5] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

[6] These publications are in press and should be available early 1968.

[7] Available from the Office of Standard Reference Data, National Bureau of Standards, Washington, D.C. 20234.

[8] Available from Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P. O. Box Y, Oak Ridge, Tenn. 37831.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume **51**, No. 11, November 1967. 15 cents. Annual subscription: \$1.50. 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, \$5; foreign, \$6. Single copy, \$1.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, \$2.25; foreign, \$2.75. Single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, \$2.75; foreign, \$3.50. Single copy, 75 cents.

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Correlations for predicting leakage through closed valves, J. Hord, Tech. Note 355 (Aug. 1, 1967), 20 cents.

Designs for surveillance of the volt maintained by a small group of saturated standard cells, W. G. Eicke and J. M. Cameron, Tech. Note 430 (Oct. 9, 1967), 20 cents.

Realistic uncertainties and the mass measurement process. An illustrated review, P. E. Pontius and J. M. Cameron, Mono. 103 (Aug. 15, 1967), 20 cents.

Selected values of electric dipole moments for molecules in the gas phase, R. D. Nelson, Jr., D. R. Lide, Jr., and A. A. Maryott, NSRDS-NBS-10 (Sept. 1, 1967), 40 cents. (Supersedes the data on dipole moments included in NBS Circ. 537.)

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Standard x-ray diffraction powder patterns, H. E. Swanson, H. F. McMurdie, M. C. Morris, and E. H. Evans, Mono. 25, Sect. 5 (Aug. 31, 1967), 55 cents.

X-ray wavelength conversion tables and graphs for qualitative electron probe microanalysis, K. F. J. Heinrich and M. A. M. Giles, Tech. Note 406 (Sept. 25, 1967), 70 cents.

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Determination of bound styrene in insoluble emulsion polymerised styrene-butadiene copolymers, M. A. Post, J. Appl. Chem. **17**, 203–208 (July 1967).

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